RH, Macdonald D, et al. Repair of interrupted aortic arch in infancy. J Thorac Cardiovasc Surg 1988;96:564-8.

**12/8/78755**

## Alpha-stat acid-base regulation during cardiopulmonary bypass

*To the Editor:*

I read with interest the recent study by Patel and associates,[1] particularly their opening comments that the issue of differing acid-base regulation "has not been tested in a relatively large trial of patients having CABG [coronary artery bypass grafting] alone." This is erroneous. Their lack of referral to a previous study by my colleagues and myself[2] is surprising considering that it was published in this same journal just 1 year previously. Their omission is all the more surprising because their results essentially confirm our observations that 2 months after the operation the incidence of cognitive dysfunction is reduced in patients having CABG who undergo cardiopulmonary bypass for longer than 90 minutes using alpha-stat management. It should be noted that the population they operated on were significantly younger than those we reported, the upper limit of their 95% confidence interval for age being less than the mean age of our population. Fundamentally, however, given differences in patient age and type of cognitive testing performed, the results of these two studies are quite comparable.

I am also puzzled by the authors statement that "there was a significantly greater reduction in $CMRO_2$ [cerebral metabolic rate for oxygen] in the pH-stat group during hypothermia." It is certainly not clear either from Fig. 3 or from the discussion on cerebral metabolism that, in fact, there was any significant difference in $CMRO_2$ between the alpha-stat and the pH-stat groups. What was the statistical strength of this observation? In a previous study, we[3] did not find any significant difference in $CMRO_2$ between groups despite cerebral blood flow (CBF) that was more than 50% lower in the alpha-stat group.

With respect to the absolute values of CBF and $CMRO_2$ that Dr. Patel's group measured, they do appear to be significantly higher than those same values that we had reported during cardiopulmonary bypass.[3] Although all of the factors mentioned by the authors, specifically, differences in perfusion technique and pressure management, can influence cerebral hemodynamics, it should also be borne in mind that anesthetics can have a significant influence on both CBF and $CMRO_2$. Accordingly, the patients that we had previously reported[3] received significantly higher doses of narcotic (fentanyl 0.1 mg/kg and a high dose of diazepam, 0.5 mg/kg), whereas their patients received 2 to 4 mg midazolam and 0.01 to 0.02 mg/kg fentanyl. I believe that when these fundamental differences in anesthetic management are taken into account, their CBF physiology measurements and those that we previously reported will be increasingly compatible.

Overall, the authors are to be congratulated for this study combining intraoperative cerebral physiology and postoperative cognitive performance.

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REFERENCES

1. Patel RL, Turtle MR, Chambers DJ, James DN, Newman S, Venn GE. Alpha-stat acid-base regulation during cardiopulmonary bypass improves neuropsychologic outcome in patients undergoing coronary artery bypass grafting. J Thorac Cardiovasc Surg 1996;111:1267-79.
2. Murkin JM, Martzke JS, Buchan AM, Bentley C, Wong CJ. A randomized study of the influence of perfusion technique and pH management strategy in 316 patients undergoing coronary artery bypass surgery. II. Neurologic and cognitive outcomes. J Thorac Cardiovasc Surg 1995;110:349-62.
3. Murkin JM, Farrar JK, Tweed WA, McKenzie FN, Guiraudon G. Cerebral autoregulation and flow/metabolism coupling during cardiopulmonary bypass: the influence of $PaCO_2$. Anesth Analg 1987;66:825-32.

**12/8/78752**

*Reply to the Editor:*

My coauthors and I would like to thank Professor Murkin for his comments relating to our article.[1] He neatly combines complimentary comments with a slight admonition relating to our unfortunate error in failing to cite his excellent study,[2] published in this Journal in August 1995, in which he addresses the issue of cognitive dysfunction and the effects of acid-base regulation during cardiopulmonary bypass (CPB) in patients undergoing coronary artery bypass grafting (CABG). In our defense, we can only apologize for this omission and state that our original manuscript was submitted to the Journal at the beginning of August 1995; invariably, our copy of the Journal does not arrive in the United Kingdom until 1 to 2 months later. Additionally, Professor Murkin cites our work in his study (reference 18), attributing it to *The Annals of Thoracic Surgery* as "in press"; this, however, is erroneous because we had never submitted the study to this journal although it had been submitted some 18 months previously to *Anesthesiology!*

We agree that our results essentially confirm those described in Professor Murkin's article. We also observed a significant reduction in cognitive dysfunction in the alpha-stat managed group of patients (20% vs 49% in the pH-stat group) at 6 weeks after the operation; these data compare well with the respective values (27% vs 44%) in the study by Murkin and colleagues at 2 months after the operation. However, differences in cognitive dysfunction between the acid-base management regimens in Murkin's study were not observed when all patients were taken into account; the above differences were observed only in those patients with CPB durations in excess of 90 minutes. In our study, all patients were included; the number of patients with CPB durations greater than 90 minutes in our study groups was 10

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of 35 (29%) in the pH-stat group and 7 of 35 (20%) in the alpha-stat group. Further analysis of this subgroup of patients showed that 7 of the 10 pH-stat patients (70%) had cognitive dysfunction in two or more tests (which was the same as for the whole group at this level) whereas only 1 of the 7 alpha-stat patients (14%) had cognitive dysfunction at the same level (compared with 46% for the whole group). This discrepancy further emphasizes the advantage bestowed by the use of alpha-stat acid-base management of CPB on reducing cognitive dysfunction compared with pH-stat management.

Professor Murkin further points out that there appears to be a considerable difference in the ages of the patients between the two studies. His statement is based on the upper limit of the confidence interval for our patient population being less than the mean value for his population. Further analysis does not support this contention, however. We concede that the use of 95% confidence intervals for mean values of parameters such as age, CPB duration, and crossclamp duration may not be ideal. In Table III of Murkin's study, it is not stated whether the mean values are given with standard deviation or standard error; we assume it to be standard deviation because this was used in Table V. On this basis, the mean age ($\pm$ standard deviation) of our patients was 56.9 $\pm$ 5.7 years for the alpha-stat group and 57.6 $\pm$ 7.8 years for the pH-stat group. These ages would not appear to be significantly younger than those in Murkin's study. In addition, our aortic crossclamp durations were 39.7 $\pm$ 10.8 minutes and 40.3 $\pm$ 14.7 minutes and CPB durations were 75.1 $\pm$ 17.3 minutes and 83.4 $\pm$ 38.7 minutes for the alpha-stat and pH-stat groups, respectively. Consequently, although the aortic crossclamp durations were similar, the mean CPB durations of our patients do appear to have been shorter.

Professor Murkin professes to be puzzled with our finding that "there was a significantly greater reduction in $CMRO_2$ [cerebral metabolic rate for oxygen] in the pH-stat group during hypothermia." We admit that it is not immediately obvious from Fig. 3 that these values are significantly different. However, the *Results* section states that $CMRO_2$ decreases by 49% and by 63% of the prebypass value in the alpha-stat and pH-stat groups, respectively. The actual values were 0.561 and 0.432 ml oxygen $\cdot$ 100 $gm^{-1} \cdot min^{-1}$, respectively, and the $p$ value for the difference between these values was 0.0064. Thus we stand by our statement that the value of $CMRO_2$ for the pH-stat group of patients, during the hypothermic phase of CPB, was reduced significantly more than in the alpha-stat group.

Professor Murkin also comments on the apparently significantly higher values of cerebral blood flow (CBF) and $CMRO_2$ obtained in our study compared with those of a previous study[3] conducted by his group. He points out that the difference observed between these studies could be accounted for by the differences in anesthetics administered during the operative procedure. We agree that anesthetic agents are among the factors that can influence cerebral hemodynamics. We also consider that the depth of anesthesia is important and would respectfully point out that we acknowledged such in the *Discussion* of our article, citing Professor Murkin's study[3] as an example of where this might be the case. However, it is the changes in CBF and $CMRO_2$ that are of interest; the initial baseline values are, essentially, irrelevant (so long as they fit within the accepted normal values). In addition, we should point out that, in our study, continuous on-line arterial blood monitoring was practiced, which enabled precise control of acid-base status in both the alpha-stat and pH-stat groups. This precise control was not practiced by Murkin and colleagues.

We thank Professor Murkin for his overall congratulations regarding our study, which we readily reciprocate. Now that there are two relatively large trials demonstrating the benefits of alpha-stat acid-base management during CPB on reducing cerebral dysfunction in patients having CABG alone, we hope that other centers that currently do not use the alpha-stat management regimen during CPB may be persuaded of the benefits.

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REFERENCES

1. Patel RL, Turtle MR, Chambers DJ, James DN, Newman S, Venn GE. Alpha-stat acid-base regulation during cardiopulmonary bypass improves neuropsychologic outcome in patients undergoing coronary artery bypass grafting. J Thorac Cardiovasc Surg 1996;111:1267-79.
2. Murkin JM, Martzke JS, Buchan AM, Bentley C, Wong CJ. A randomized study of the influence of perfusion technique and pH strategy in 316 patients undergoing coronary artery bypass surgery. II. Neurologic and cognitive outcomes. J Thorac Cardiovasc Surg 1995;110:349-62.
3. Murkin JM, Farrar JK, Tweed WA, McKenzie FN, Guiraudon G. Cerebral autoregulation and flow/metabolism coupling during cardiopulmonary bypass: the influence of $PaCO_2$. Anesth Analg 1987;66:825-32.

**12/8/78753**

## Median sternotomy for prolonged resuscitation in neonatal tetralogy of Fallot with absent pulmonary valve

*To the Editor:*

In a recent brief communication, van Son and Mohr[1] discussed specific preoperative strategies designed to stabilize the condition of neonates who have tetralogy of Fallot with absent pulmonary valve syndrome.

We recently encountered a neonate with tetralogy of Fallot and absent pulmonary valve who failed to respond to the "usual" preoperative maneuvers designed specifically for the associated bronchial compression and severe respiratory distress. Preoperative nursing in the prone position and median sternotomy may be advantageous, as previously described by Heinemann and Hanley[2] and van Son and Mohr.[1] However, depending on the associated anatomic lesions, these selected maneuvers may be useless, as described below.

A female neonate (2.6 kg) was intubated 2 hours after birth because of cyanosis and respiratory insufficiency and was transferred to our institution. Because of the patient's instability a limited transthoracic echocardiogram was